NOAA TM NWS WR69

UNITED STATES DEPARTMENT OF COMMERCE PUBLICATION

NOAA Technical Memorandum NWS WR69

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

National Weather Service Support To Soaring Activities

ELLIS B. BURTON

copy to:
DEN
CYS
CDS
PUB
PSM
ICT
DDC

Western Region

SALT LAKE CITY, UTAH

AUGUST 1971

NOAA TECHNICAL MEMORANDA
National Weather Service, Western Region Subseries

The National Weather Service (NWS) Western Region (WR) Subseries provides an informal medium for the documentation and quick dissemination of results not appropriate, or not yet ready, for formal publication. The series is used to report on work in progress, to describe technical procedures and practices, or to relate progress to a limited audience. These Technical Memoranda will report on investigations devoted primarily to regional and local problems of interest mainly to personnel, and hence will not be widely distributed.

Papers 1 to 23 are in the former series, ESSA Technical Memoranda, Western Region Technical Memoranda (WRTM); papers 24 to 59 are in the former series, ESSA Technical Memoranda, Weather Bureau Technical Memoranda (WBTM). Beginning with 60, the papers are part of the series, NOAA Technical Memoranda NWS.

Papers 1 to 23, except for 5 (revised edition) and 10, are available from the National Weather Service Western Region, Scientific Services Division, P. O. Box 11188, Federal Building, 125 South State Street, Salt Lake City, Utah 84111. Papers 5 (revised edition), 10, and all others beginning with 24 are available from the National Technical Information Service, U.S. Department of Commerce, Sills Bldg., 5285 Port Royal Road, Springfield, Va. 22151. Price: $3.00 paper copy; $0.95 microfiche. Order by accession number shown in parentheses at end of each entry.

ESSA Technical Memoranda

WRTM 1 Some Notes on Probability Forecasting. Edward D. Diemer, September 1965. (Out of print.)
WRTM 2 Climatological Precipitation Probabilities. Compiled by Lucianne Miller, December 1965.
WRTM 3 Western Region Pre- and Post-FP-3 Program, December 1, 1965 to February 20, 1966. Edward D. Diemer, March 1966.
WRTM 4 Use of Meteorological Satellite Data. March 1966.
WRTM 5 Station Descriptions of Local Effects on Synoptic Weather Patterns. Philip Williams, Jr., April 1966 (revised November 1967, October 1969). (PB-178000)
WRTM 6 Improvement of Forecast Wording and Format. C. L. Glenn, May 1966.
WRTM 7 Final Report on Precipitation Probability Test Programs. Edward D. Diemer, May 1966.
WRTM 8 Interpreting the RAREP. Herbert P. Benner, May 1966 (revised January 1967). (Out of print.)
WRTM 9 A Collection of Papers Related to the 1966 NMC Primitive-Equation Model. June 1966.
WRTM 10 Sonic Boom. Loren Crow (6th Weather Wing, USAF, Pamphlet), June 1966. (Out of print.) (AD-479366)
WRTM 11 Some Electrical Processes in the Atmosphere. J. Latham, June 1966.
WRTM 12 A Comparison of Fog Incidence at Missoula, Montana, with Surrounding Locations. Richard A. Dightman, August 1966. (Out of print.)
WRTM 13 A Collection of Technical Attachments on the 1966 NMC Primitive-Equation Model. Leonard W. Snellman, August 1966. (Out of print.)
WRTM 14 Application of Net Radiometer Measurements to Short-Range Fog and Stratus Forecasting at Los Angeles. Frederick Thomas, September 1966.
WRTM 15 The Use of the Mean as an Estimate of "Normal" Precipitation in an Arid Region. Paul C. Kangieser, November 1966.
WRTM 16 Some Notes on Acclimatization in Man. Edited by Leonard W. Snellman, November 1966.
WRTM 17 A Digitalized Summary of Radar Echoes Within 100 Miles of Sacramento, California. J. A. Youngberg and L. B. Overaas, December 1966.
WRTM 18 Limitations of Selected Meteorological Data. December 1966.
WRTM 19 A Grid Method for Estimating Precipitation Amounts by Using the WSR-57 Radar. R. Granger, December 1966. (Out of print.)
WRTM 20 Transmitting Radar Echo Locations to Local Fire Control Agencies for Lightning Fire Detection. Robert R. Peterson, March 1967. (Out of print.)
WRTM 21 An Objective Aid for Forecasting the End of East Winds in the Columbia Gorge, July through October. D. John Coparanis, April 1967.
WRTM 22 Derivation of Radar Horizons in Mountainous Terrain. Roger G. Pappas, April 1967.
WRTM 23 "K" Chart Applications to Thunderstorm Forecasts Over the Western United States. Richard E. Hambidge, May 1967.

ESSA Technical Memoranda, Weather Bureau Technical Memoranda (WBTM)

WBTM 24 Historical and Climatological Study of Grinnell Glacier, Montana. Richard A. Dightman, July 1967. (PB-178071)
WBTM 25 Verification of Operational Probability of Precipitation Forecasts, April 1966-March 1967. W. W. Dickey, October 1967. (PB-176240)
WBTM 26 A Study of Winds in the Lake Mead Recreation Area. R. P. Augulis, January 1968. (PB-177830)
WBTM 27 Objective Minimum Temperature Forecasting for Helena, Montana. D. E. Olsen, February 1968. (PB-177827)
WBTM 28 Weather Extremes. R. J. Schmidli, April 1968 (revised July 1968). (PB-178928)
WBTM 29 Small-Scale Analysis and Prediction. Philip Williams, Jr., May 1968. (PB-178425)
WBTM 30 Numerical Weather Prediction and Synoptic Meteorology. Capt. Thomas D. Murphy, U.S.A.F., May 1968. (AD-673365)
WBTM 31 Precipitation Detection Probabilities by Salt Lake ARTC Radars. Robert K. Belesky, July 1968. (PB-179084)
WBTM 32 Probability Forecasting--A Problem Analysis with Reference to the Portland Fire Weather District. Harold S. Ayer, July 1968. (PB-179289)
WBTM 33 Objective Forecasting. Philip Williams, Jr., August 1968. (AD-680425)
WBTM 34 The WSR-57 Radar Program at Missoula, Montana. R. Granger, October 1968. (PB-180292)
WBTM 35 Joint ESSA/FAA ARTC Radar Weather Surveillance Program. Herbert P. Benner and DeVon B. Smith, December 1968 (revised June 1970). (AD-681857)
WBTM 36 Temperature Trends in Sacramento--Another Heat Island. Anthony D. Lentini, February 1969. (Out of print.) (PB-183055)
WBTM 37 Disposal of Logging Residues Without Damage to Air Quality. Owen P. Cramer, March 1969. (PB-183057)
WBTM 38 Climate of Phoenix, Arizona. R. J. Schmidli, P. C. Kangieser, and R. S. Ingram. April 1969. (Out of print.) (PB-184295)
WBTM 39 Upper-Air Lows Over Northwestern United States. A. L. Jacobson, April 1969. (PB-184296)
WBTM 40 The Man-Machine Mix in Applied Weather Forecasting in the 1970s. L. W. Snellman, August 1969. (PB-185068)
WBTM 41 High Resolution Radiosonde Observations. W. S. Johnson, August 1969. (PB-185673)
WBTM 42 Analysis of the Southern California Santa Ana of January 15-17, 1966. Barry B. Aronovitch, August 1969. (PB-185670)
WBTM 43 Forecasting Maximum Temperatures at Helena, Montana. David E. Olsen, October 1969. (PB-185762)
WBTM 44 Estimated Return Periods for Short-Duration Precipitation in Arizona. Paul C. Kangieser, October 1969. (PB-187763)
WBTM 45/1 Precipitation Probabilities in the Western Region Associated with Winter 500-mb Map Types. Richard A. Augulis, December 1969. (PB-188248)

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

NOAA Technical Memorandum NWSTM WR-69

NATIONAL WEATHER SERVICE SUPPORT TO SOARING ACTIVITIES

Ellis B. Burton
Aviation Service Meteorologist
Western Region Headquarters
Salt Lake City, Utah

WESTERN REGION
TECHNICAL MEMORANDUM NO. 69

SALT LAKE CITY, UTAH
AUGUST 1971

TABLE OF CONTENTS

LIST OF FIGURES

NATIONAL WEATHER SERVICE SUPPORT TO SOARING ACTIVITIES

I. INTRODUCTION

Soaring activity and the increasing requirement for National Weather Service support can be enhanced by a better understanding of the part meteorology plays in contest planning. From early spring into late fall, Western Region Staff Minutes frequently describe meteorological support at local, regional, and national soaring contests. Soaring and the requirement for meteorological support are steadily increasing throughout the country. Some of the best soaring sites and soaring weather in the world are located in the Western Region. The current world's altitude record (46,267 feet) was established in a wave over the Tehachapi Mountains of southern California. During the national soaring contest held at Reno in 1966, several contestants made distance flights reaching the Pocatello area. A flight from San Diego eastward into western Texas held the two-place distance record at one time.

To give Western Region personnel a better feel for soaring, excerpts from Soaring Society of America (SSA) publications [1] have been prepared. In addition, a forecast manual covering the meteorology of soaring and questions commonly asked by soaring pilots, written by Charles V. Lindsay, Quality Control Officer (QCO), Weather Service Forecast Office (WSFO), Washington, D. C., will be distributed to the field in the near future.

II. THE NATURE OF SOARING

Almost everyone knows that soaring is a part of aviation, but relatively few of the general public know the exact part it plays. Soaring, or gliding as it used to be called, bears the same relation to power flying that sailing does to power boating. To the amateur, it offers a superb sport which challenges his skill and offers a scope to his talents far beyond those required for the management of powered aircraft. For the professional it offers relaxation and a chance to perfect his skill to an extent that is not possible in powered aircraft. It has long been said that one cannot call himself a true seaman unless he has served under sail. In like fashion, there is no powered aircraft pilot, however experienced, who cannot improve his technique by soaring experience.

Sailplanes, as modern high-performance gliders are called, are used to some extent for aerodynamic and meteorological research; and cargo and troop-carrying gliders were used for military purposes by the major powers in World War II. But modern soaring, the art of motorless flight, is primarily recreational.

A soaring pilot may stay aloft for hours, and perhaps fly many miles across the countryside using his superior knowledge of air currents.

Some of the various types of lift are illustrated in Figure 1. Soaring is a sport of great challenge—a game for which the rules have not been completely written, played on a field that has no posted boundaries. The variety of experiences available to the player is virtually unlimited, and each one can participate to a degree compatible with his or her ambition, ability, and equipment.

III. HISTORY - SOARING CONTESTS

Soaring is frequently conducted at sites fairly distant from population centers. It is a sport that the public at large knows very little about. Furthermore, soaring competitions usually are unrewarding as a spectator sport because the objective of many contests is to get as far from the take-off site as possible. A notable exception is the annual Torrey Pines Soaring Championships held each year near San Diego. Here dozens of sailplanes glide up and down the cliffs along the ocean before the eyes of thousands of spectators.

In soaring, as in many other types of contests, speed makes winners. This hasn't always been so. The "Whatever you can do I can do better" spirit in motorless flying really got under way in Germany 50 years ago this summer. Although the Wright Brothers had soared for nearly 10 minutes in 1911, the competitive thrust was seemingly ignited by a two-minute flight that carried a sailplane above its launch point on the fabled Wasserkuppe in 1920. Records were soon being broken as fast as they were set. Initially the desire to excel found outlet in rapidly increasing duration times ("Who can stay up longest?"); and then cross-country distance ("Who can fly farthest?").

The burgeoning German motorless flying movement of the century's second and third decades gave that country undisputed pre-eminence in the soaring world. At that period the most prized quality of sailplane design was the ability to sustain--to stay aloft. As a result, ships of those days possessed the ability to "float" miraculously and spiral slowly in weak updrafts. However, once they left lift and began to glide, pilots had to be content with their slow speed. It took time to cover ground; any significant increase in speed steepened the glide angle tremendously.

What was needed was a sailplane that could "penetrate"--fly rapidly without spoiling its glide angle and yet be able to circle slowly enough to stay in narrow, weak thermals. Thus speed ("Who can fly fastest?") became the key measure of competitive skill.

IV. MODERN DAY SOARING CONTESTS

After World War II, duration and altitude events disappeared from the contests. Competitors now vied with one another for the fastest time around closed courses. Distance events still remain; but since competent pilots are now able to stay aloft during a given number of daylight hours, here, too, victory becomes a function of speed. The fastest pilot and ship win because they cover the most miles and earn the most points.

But how can you tell who's winning? That's easy--it's the pilot who has the most cumulative points. Each day a pilot places first he is awarded 1000 points. If there were 10 events and he won them all, he'd end up with 10,000 points. A simple proportional formula prorates points for runners-up. The daily scoring sheets and the scoring board usually located in front of the spectator area will tell you results of both individual tasks and the cumulative leader.

During contests there is a frequent change of leadership, with different names appearing at the top. It is possible, however, to win a meet without even winning a single event. A. J. Smith, a former U. S. and World champion, did just that in the 1968 Internationals at Lesno, Poland. His best placement on any day was second, yet he accumulated enough points by staying near the top to win the meet by a margin of 136 points.

The contest-wise pilot is a tactician who plans and relates his point and flight strategies. He willingly concedes a battle to win the war. He knows it is much more important, generally, to finish a task than to be first for the day. Though he flies aggressively, he husbands altitude and is content to let a competitor pass him if the area weather indicates caution. He knows there is always a chance the eager one's gamble will pay off and that his name will be on the top of the next day's score sheet. But veterans are not panicked at the sight of go-for-broke pilots screaming by under such circumstances. A miss or two and their standing sinks dramatically down in the column.

Next to weather itself, the success of a contest is determined by the skill of the Task Committee in performing its vital function. If it can match the specific day's conditions, the task and the competitive capabilities of the contestants, all is right with the soaring world.

Any expert in tests and measurements will tell you a good test differentiates--it is neither too hard nor too easy, so that neither too many nor too few complete the task assigned. If there is a wide spread between achievements of the best and poorest and if there is little bunching in between, the tester has chosen the task well.

Each morning of the contest the committee will obtain the latest area weather information and predictions from its meteorologists and decide upon the event of the day. If it chooses a speed run, it will establish a course between specified points which will achieve this desired separation. These points may be chosen to take advantage of such phenomena as convergences or shear lines; or, on the other hand, force the contestants to show their ability in circumventing weather or topographical challenges.

Most frequently the course is triangular or out-and-return so that the race begins and ends at the field. Pairs of cameras mounted in each sailplane enable judges to verify that pilots made turns at the prescribed points. Each night the films are processed to corroborate the pilots' claims.

If a distance task is selected, there will probably be at least one "free distance" day. The contestants are to go as far as they can and, unlike all other events, are free to choose their routes and directions. The ability to assess, recognize, and utilize weather is the quintessence of soaring, and many feel the free-distance task is the ultimate test. But modern sailplanes and skills now achieve such distances that retrieval time and expense may force this event out of contests.

To retain distance tasks but avoid long drives for sailplane retrieval, several other options exist which permit exercise of some weather judgment while flying a variety of course patterns. Consecutive distances for these patterns are then totaled; this assures that the pilot will land within 175 miles or less from his starting point. Most popular among these is "Distance Within a Prescribed Area", sometimes called the "cat's cradle" (See Figure 2).

Ideally, the fairest thing in a speed race would be a "race-horse start" where all ships crossed over the starting line at the same instant. However, this would pose a problem in logistics. Where could you get 65 towplanes and pilots?--see Figure 3 for methods of launch. Also, safety must be considered--imagine the reactions of the FAA watching 65 sailplanes milling around in the first thermal after the start!

The release from tow does not, therefore, signal the beginning of competition; the pilot must still run through the official "starting gate" at what he judges to be the most opportune time. This is an imaginary window in the sky monitored by the official starters. With some simple but ingenious instruments, the dimensions can be clearly seen by officials. The most important measurement is the upper one--1,000 meters above the field. There is no limit to the speed a pilot may fly through the starting gate (other than the safety of his ship), but he may not exceed the prescribed altitude. Altitude translates to speed and/or distance points on the day's final scores.

Like eager sprinters, some pilots "test" starters by shaving this upper limit as closely as they dare. If they miss, the starters quickly inform them by radio, and they must go back and make another run--sometimes several--before "good start" clears them to proceed on course. Their precise starting time is recorded for comparison with their finishing time. The scorer later determines the elapsed total and official speed. Nonfinishers get "distance points"; but falling short of the airport is reflected in far fewer points than if the pilot completes the task.

Except for the excitement at the finish gate, a soaring contest is like a play where all the action and drama occur off stage. After the last contestant has made his start and headed out on course, a restless quietude settles upon the field. It is curiously reminiscent of a military field in wartime. How many will make it back? Who will go down? Soaring pilots have no rooters as do athletes in major sports. Nevertheless, there are partisan enthusiasts who know the ships and competition numbers of the main competitors as well as those of their own pilot. As if by prearrangement, these hardy souls begin to move toward the finish line at a certain point in the afternoon. They have estimated arrival times of early finishers, based upon mileage of the day's course and an educated guess at speeds to be achieved.

Here at last, from the spectator's point of view, is something to see. All eyes now turn toward the quadrant of the horizon from which finishers are expected. Before the first sightings, the radio begins its clipped announcements to the finish gate's ground station: "CONTEST GROUND... This is Four Tango one mile out." --- "There he is!"

Perhaps someone spots the tell-tale glint of sun striking approaching sailplane. Because of the small frontal area of high-performance sailplanes as they aim for the finish line, it is difficult to spot ships at a distance. Unless they are bucking a headwind, they always seem quite low, so flat are their glide angles.

Now an error of judgment may be exposed for all to see. If final glide was begun too low, watchers are treated to the spectacle of a contestant falling short of the field or scratching desperately about searching for one last bit of lift to save the flight. It has even happened that some have barely made it to the runway only to miss crossing the finish line by a few feet on the roll-out.

On the other hand, those who have erred on the conservative side arrive with an excess of altitude. A steeper glide, while giving more speed, would exceed the design limit for which the ship is legally placarded ("red-line" speed). This is inviting disaster in the form of structural failure.

But those who have planned well come hissing by the finish line at perhaps 100 mph or better, just a few feet above ground. Though it brings forth many "ohs" and "ahs", the low pass is really not a grandstand play. It is the calculated tactic of pilots who have been splitting seconds by balancing altitude and speed to yield a maximum point return, not only during the spectacular final glide but throughout every moment of the entire task.

As sailplane design and structures have become more sophisticated and complex, their costs have risen accordingly. Some years ago the Federation Aeronautique Internationale (FAI), the international governing body under whose auspices championships are held, observed that fine pilots might be prevented from competing because of this growing expense. At that time the Standard Class, as distinct from the Open Class, was established to encourage safe, practical, and inexpensive ships.

The main restriction on standard class was the limiting of wingspan to 15 meters. This is roughly analogous to efforts at holding down engine displacements in auto racing. Also forbidden were such expensive features as retractable landing gears and wind flaps; but these latter restrictions are now falling by the wayside. Thus, the effort has been only partially successful; and some of the Standard Class sailplanes are veritable jewels and just about as costly as Open-Class planes. But the breed has been improved by the care and attention lavished on detail.

V. A DAY IN THE LIFE OF A SOARING CONTEST METEOROLOGIST

The first word must be "hectic". Life begins at the crack of dawn as the meteorologist starts his frantic search for clues on the strength, duration, and timing of the day's "lift potential"--the soaring pilot translates lift and its associated altitude into distance and speed. As previously mentioned, the first meeting of the day is between meteorologist and contest Task Committee, normally held around 8:30 a.m. local time. The general pilots' meeting follows at about 9:30 a.m. with announcement of the day's task, a meteorological briefing and various regulations and safety precautions covering events of the day (see Figure 4 illustrating display board used at 1970 soaring championships at Marfa, Texas). Safety has long been a key word in soaring, as shown by frequent safety articles in the Soaring Society's monthly publication.

Between dawn and the meeting with the Task Committee, the meteorologist gathers his material. Hopefully, the soaring site has teletype Services A and C, as well as National Facsimile. Excellent use is made of fire-weather mobile units with their radio facsimile. Arrangements are made for the fire-weather transmitting site to tape early morning significant weather progs for transmission to the soaring site. At 1200Z, if there is no raob at the field, a local aircraft sounding is made. The aircraft altimeter is preset to 29.92 inches prior to take-off; and with use of an outside air temperature instrument, a temperature profile is taken up to 7,000 to 10,000 feet above ground level. Temperature readings are taken every 500 feet and at other significant points of temperature change, cloud bases, bases and tops of haze or smoke layers, etc. This sounding, along with network raobs within a 500-mile radius of the contest site, is analyzed to give the meteorologist his air mass picture.

The meteorologist needs to establish the time thermal life will begin, what the thermal strength will be, and the height thermals will reach at onset of the soaring day, as well as during maximum lift periods. This information is given to pilots so they can use it directly in their flight planning. Winds at various altitudes are essential, along with the possibility of "overdevelopment"--clouds becoming broken to overcast and cutting off further heating and its associated thermals. Scattered thunderstorms along the path of the flight pose a question for the pilot: "In what direction will the cirrus blow-off move?" This also can stop or greatly diminish further thermal activity. Surface winds exceeding 20 knots frequently spread thermal activity into unusable small patches and can hamper launch and return of contest aircraft.

When contests are held in or near mountainous areas, the forecaster must consider possible mountain wave action and the effect this could have on the daily task.

After the general pilots' meeting, the forecaster normally conducts individual briefings for many of the contestants until take-off time, which is usually between 11 a.m. and 1 p.m. Once contestants are on course, the major portion of the meteorologist's work is at an end. However, information on how the day's weather forecast verified holds him on the job, as this will influence his evaluation on the following day. This can best be obtained by talking with pilots after their return from a three- to six-hour flight. So, the weather support team at a soaring contest must endure long days and constant forecast pressure; but on the rewarding side is the challenge of an operational forecast prepared for users who will quickly point out errors or compliment forecast success, plus the comradeship of an aviation-oriented group. The soaring pilot, with his dependence on meteorological knowledge for motive power, is a most intent listener and a valuable source of information on microscale phenomena and its effect on flying.

Noncontest requests for meteorological support will primarily be to assist the pilot in completion of the International Soaring Awards as listed below:

(1) <u>General</u>

a. All flights must be solo.

b. The pilot must hold a current FAI Sporting License for Soaring (issued free to voting members and student members of SSA; non-member schedule of fees available on request).

c. The flight must be supervised by an SSA Official Observer (a voting member or student member of SSA who holds a C badge or better).

(2) C Badge

The pilot must take a flight of at least five minutes above his release point or some low point after release, or qualify for the badge in SSA's ABC Training Program. C Badges are issued only by designated SSA Instructors.

(3) Silver Badge

a. A cross-country flight of at least 32 miles (50 KM).

b. A flight in which an altitude gain of 3,280 feet (1,000 meters) is made above the point of release or some low point after release.

c. A duration flight of at least five hours from time of release.

(4) Gold Badge

a. A cross-country flight of at least 87 miles (300 KM).

b. A flight in which an altitude gain of 9,843 feet (3,000 meters) is made above the point of release or some low point after release.

c. A duration flight of at least five hours from time of release (may be same flight which qualifies for Silver Badge duration).

(5) Diamond Badge

a. A cross-country flight of at least 311 miles (500 KM).

b. A cross-country flight of at least 187 miles (300 KM) to a predesignated goal.

c. A flight in which an altitude gain of 16,404 feet (5,000 meters) is made above the point of release or some low point after release.

VI. REFERENCE

[1] "Soaring in America", The Soaring Society of America, Incorporated, 1959.

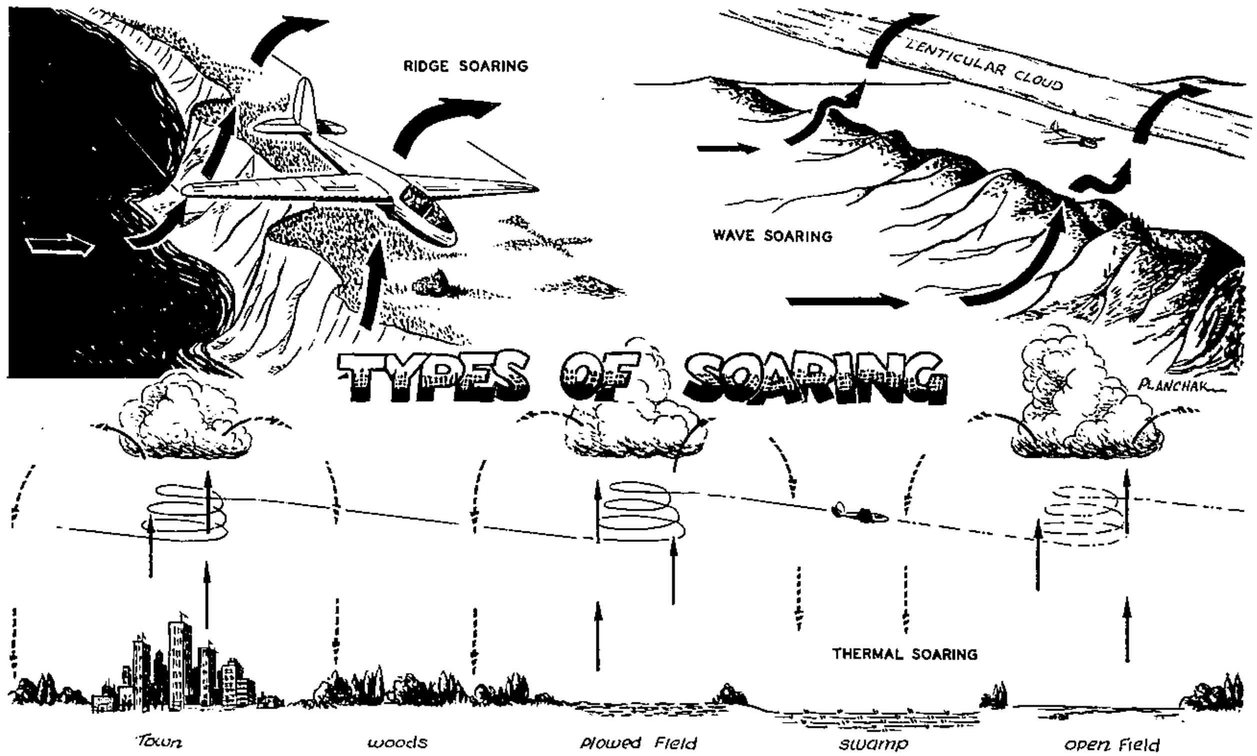


FIGURE 1. TYPES OF SOARING.

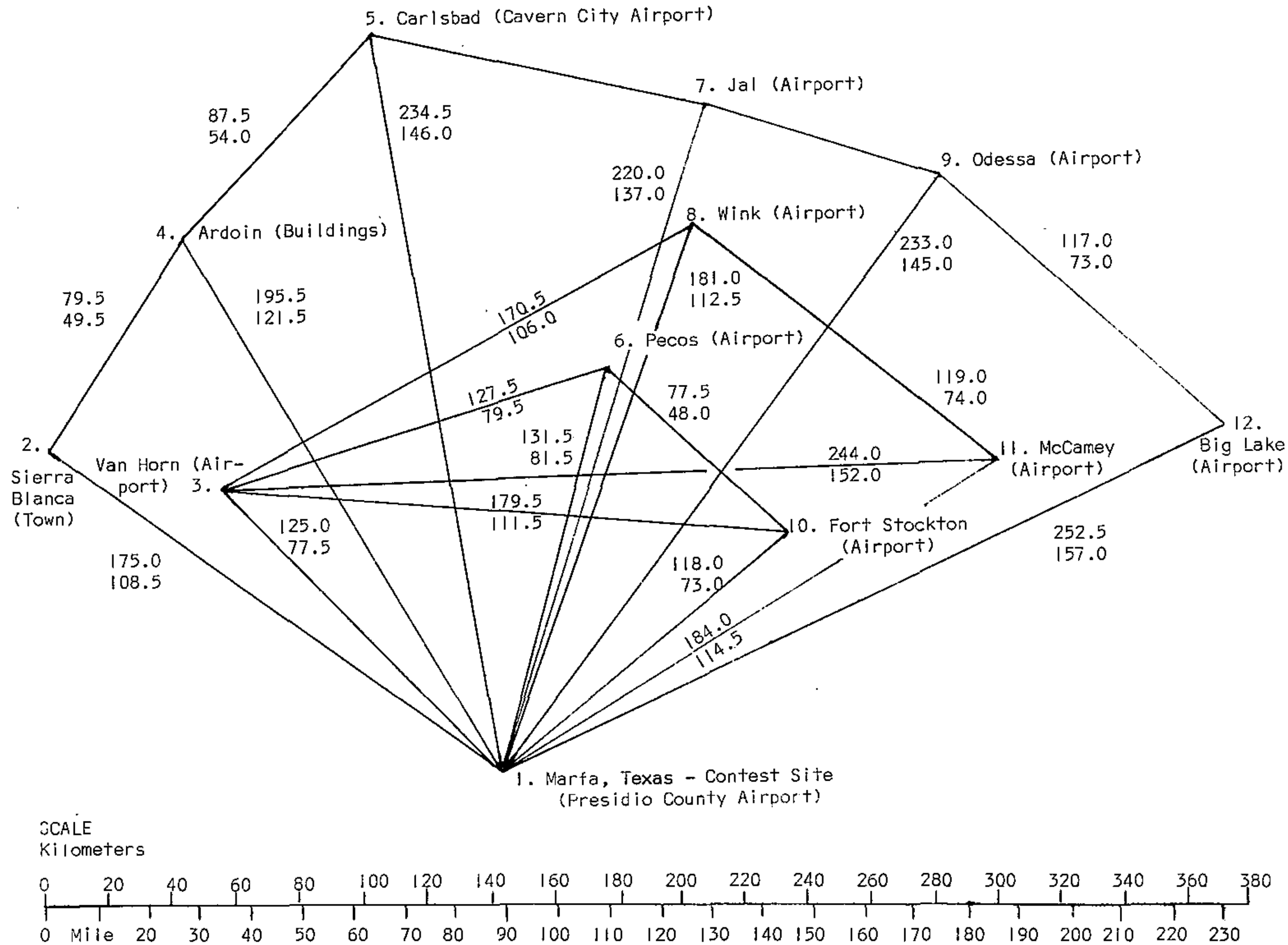


FIGURE 2

12TH WORLD SOARING CHAMPIONSHIPS - JUNE 21 - JULY 4, 1970

DIAGRAM OF TURN POINTS - DISTANCES BETWEEN POINTS ARE GIVEN IN KILOMETERS (UPPER FIGURES) AND STATUTE MILES (LOWER FIGURES).

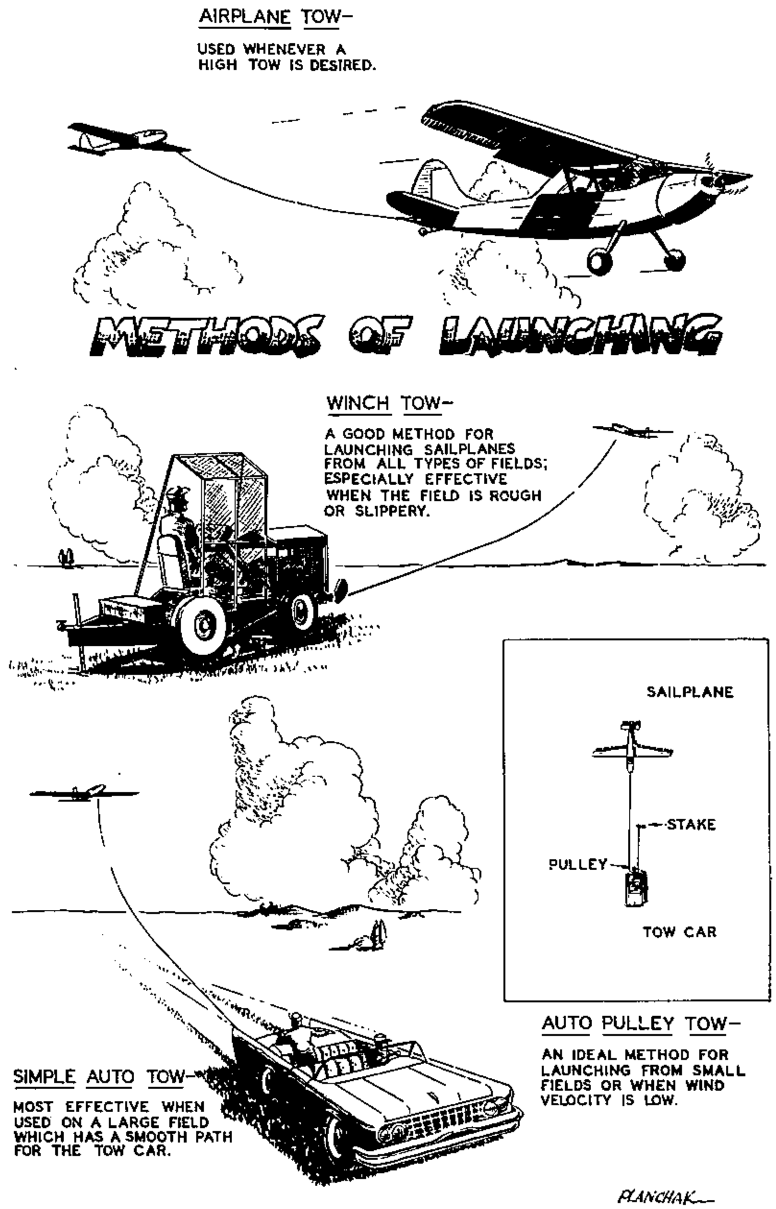


FIGURE 3. METHODS OF LAUNCHING SAILPLANES.

TWELFTH WORLD SOARING CHAMPIONSHIPS / 1970
MARFA, TEXAS

TASK	CLASS			
TURN POINT LATITUDE LONGITUDE COURSE DISTANCE				
TURN POINT LATITUDE LONGITUDE COURSE DISTANCE				

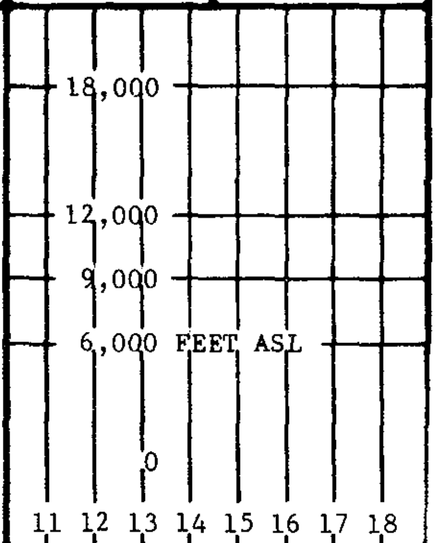
WEATHER
1200 HR. C.
1500
1800

SURFACE FORECAST/MARFA

INDEXES
STABILITY
THERMAL

WINDS
FEET ASL

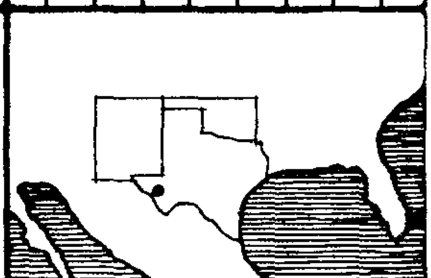
DEGREES AND KNOTS
6,000 9,000 12000 18000



THERMALS
START
MAXIMUM
END

REMARKS

HR.C. FT. ASL LIFT K.



OPERATION
GRID TIME

FINISH

GRID AREA
RELEASE

HR. OPEN CLOSE

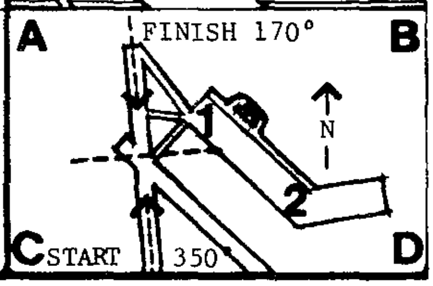


FIGURE 4

No. 45/2 Precipitation Probabilities in the Western Region Associated with Spring 500-mb Map Types. Richard P. Augulis. January 1970. (PB-189434)
No. 45/3 Precipitation Probabilities in the Western Region Associated with Summer 500-mb Map Types. Richard P. Augulis. January 1970. (PB-189414)
No. 45/4 Precipitation Probabilities in the Western Region Associated with Fall 500-mb Map Types. Richard P. Augulis. January 1970. (PB-189435)
No. 46 Applications of the Net Radiometer to Short-Range Fog and Stratus Forecasting at Eugene, Oregon. L. Yee and E. Bates. December 1969. (PB-190476)
No. 47 Statistical Analysis as a Flood Routing Tool. Robert J. C. Burnash . December 1969. (PB-188744)
No. 48 Tsunami. Richard A. Augulis. February 1970. (PB-190157)
No. 49 Predicting Precipitation Type. Robert J. C. Burnash and Floyd E. Hug. March 1970. (PB-190962)
No. 50 Statistical Report of Aeroallergens (Pollens and Molds) Fort Huachuca, Arizona 1969. Wayne S. Johnson. April 1970. (PB-191743)
No. 51 Western Region Sea State and Surf Forecaster's Manual. Gordon C. Shields and Gerald B. Burdwell. July 1970. (PB-193102)
No. 52 Sacramento Weather Radar Climatology. R. G. Pappas and C. M. Veliquette. July 1970. (PB-193347)
No. 53 Experimental Air Quality Forecasts in the Sacramento Valley. Norman S. Benes. August 1970. (PB-194128)
No. 54 A Refinement of the Vorticity Field to Delineate Areas of Significant Precipitation. Barry B. Aronovitch. August 1970.
No. 55 Application of the SSARR Model to a Basin Without Discharge Record. Vail Schermerhorn and Donald W. Kuehl. August 1970. (PB-194394).
No. 56 Areal Coverage of Precipitation in Northwestern Utah. Philip Williams, Jr., and Werner J. Heck. September 1970. (PB-194389)
No. 57 Preliminary Report on Agricultural Field Burning vs. Atmospheric Visibility in the Willamette Valley of Oregon. Earl M. Bates and David O. Chilcote. September 1970. (PB-194710)
No. 58 Air Pollution by Jet Aircraft at Seattle-Tacoma Airport. Wallace R. Donaldson. October 1970. (COM-71-00017)
No. 59 Application of P.E. Model Forecast Parameters to Local-Area Forecasting. Leonard W. Snellman. October 1970. (COM-71-00016)

NOAA Technical Memoranda NWS

No. 60 An Aid for Forecasting the Minimum Temperature at Medford, Oregon. Arthur W. Fritz, October 1970. (COM-71-00120)
No. 61 Relationship of Wind Velocity and Stability to SO_2 Concentrations at Salt Lake City, Utah. Werner J. Heck, January 1971. (COM-71-00232)
No. 62 Forecasting the Catalina Eddy. Arthur L. Eichelberger, February 1971. (COM-71-00223)
No. 63 700-mb Warm Air Advection as a Forecasting Tool for Montana and Northern Idaho. Norris E. Woerner. February 1971. (COM-71-00349)
No. 64 Wind and Weather Regimes at Great Falls, Montana. Warren B. Price, March 1971.
No. 65 Climate of Sacramento, California. Wilbur E. Figgins, June 1971. (COM-71-00764)
No. 66 A Preliminary Report on Correlation of ARTCC Radar Echoes and Precipitation. Wilbur K. Hall, June 1971. (COM-71-00829)
No. 67 Precipitation Detection Probabilities by Los Angeles ARTC Radars. Dennis E. Ronne, July 1971.
No. 68 A Survey of Marine Weather Requirements. Herbert P. Benner, July 1971. (COM-71-00889)